CHAPTER VI

DISCUSSION OF TEST RESULTS AND CONCLUSIONS

6.1 Discussion of Test Results

a) Flexural of Beams

As expected, test results indicate that all main beams failed in bending as preliminary designed. No shear failure occured. All beams were generally sudden failure. The typical failure of beam DA, DB, TA and TB were crossgrain tension and splintering tension while the compression failure was not prominent and invisible. The main beams KA and KB show typical compression failure at the upper part of the beam.

The bending test of main beams showed that load carrying capacity from tests were somewhat lower than the load calculated by second degree parabola approximation of the compression side. The bending test of small specimen show that the theoretical ultimate moment of the beams were somewhat lower than the tested values of the small beams.

Table (6.1) shows that the theoretical ultimate moment of main beams with the span-depth ratio (L/h) of 17.14 and the depth-width ratio (h/b) of 3.92 is higher than the actual value about +7.10 percent. Table (6.2) shows that the theoretical ultimate moment of small beams with the span-depth ratio (L/h) of 13.53 and the depth-width ratio (h/b) of 1.02 is lower than the actual value about -19.90 percent. The average error of the theoretical value is -6.40 percent lower than the tested value which confirms that the assumed second degree parabola on the compression side is suitable approximation.

b) Strain Distribution of Main Beams

The distributions of longitudinal strain are plotted in figure (5.6), (5.7) and (5.8). The numerical values of longitudinal strain are given in table (5.2), (5.3) and (5.4). Observations of these distributions show substantially that, at ultimate load, neutral axis of the beam was not at the same position as centroidal axis of the beam, it somewhat shifts downward to the tension side as a result of stress redistribution process, The longitudinal strain distribution curve also show a linear variation across the depth of the beam. The deviations of some longitudinal strain values from the linear variation may be accounted for by the experimental limitations in the attachment of the individual strain gages. Even with the utmost care, no two strain gages can be glued to the wood exactly in the same manner, the accuracy in the oreintation of the individual strain gages with respect to the longitudinal axis of the beam can only be checked by visual alignment.

c) <u>Statistical Analysis of Test Results</u>

Bending test result of small specimens, table (3.1), (3.2) and (3.3) show that Dang, Kiem and Teng wood have the modulus of rupture vary from 1,142 ksc. to 1,438 ksc. All of them are classified by Engineering Institute of Thailand as the same class as "Hard Wood". Then consider them as the same group of statistical distribution, 18 pairs of tensile and compressive strength of these three species of wood were taken from table (3.1), (3.2) and (3.3). Coefficient of ultimate bending moment "R" then were calculated as shown in table (3.4), (3.5) and (3.6).

By usual statistical method, the mean coefficient of ultimate bending moment of these woods equal to 170.5 ksc. with standard deviation 12.03 and coefficient of variation only 7.06 percent as shown in table (6.3).

To establish safe value of coefficient "R" by using the criteria of probability of less than 1 in 100 that a random individual "R" value will be below the safe value "R". The formula for calculating the safe value "R" shall be

R = mean "R" - 2.326 $\overline{SD}$

which 2.326 is the coefficient of 1 percent probability of test falling below R

R = 170.5 - 2.326 (12.03)

= 142.5 ksc.

For rectangular cross sectional beam, modulus of rupture is six times of the coefficient of ultimate bending moment, then

Modulus of Rupture = 855 ksc.

To determine the allowable value for this group of wood, the value shall be devided by factor of safety equal to 6.

Allowable R = 23.8 ksc.

Allowable bending stress = 142.5 ksc.

It is seen that allowable bending stress 142.5 ksc. is higher than the allowable bending stress of hard wood (120ksc.) which is specified by The Engineering Institute of Thailand.

TABLE 6.1 COMPARISION OF TEST RESULTS OF MAIN BEAMS.

Main Beam	b x h cm.	Span Length (L) cm.	Ultimate Moment kg-cm.		Error %
			Estimated	Actual	
DA	5.40x21	360	439,250	438,550	+00.16
DB	5.30x21	360	373,810	324,100	+15.34
KA	5.50x21	360	401,660	349,580	+14.90
KB	5.50x21	360	391,890	381,360	+02.76
TA	5.20x21	360	302,840	289,170	+04.73
TB	5.25x21	360	399,400	381,360	+04.73

Average L/h = 17.14

Average h/b = 3.92

Average error = +7.10 %

TABLE 6.2 COMPARISON OF TEST RESULTS OF SMALL SPECIMENS.

Small Specimen	b x h cm.	Span Length (L) cm.	Ultimate Moment kg-cm.		Error %
			Theoretical	Actual	
DA 1	5.20x5.30	70	26,876	35,000	-23.23
DA 2	5.20x5.30	70	27,170	33,250	-18.28
DA 3	5.20x5.20	70	25,872	32,375	-20.08
DB 1	5.10x5.20	70	22,202	32,200	-31.05
DB 2	5.10x5.20	70	25,650	26,250	-02.28
DB 3	5.00x5.20	70	23,525	30,800	-23.62
KA 1	5.10x5.20	70	23,719	27,125	-12.56
KA 2	5.10x5.10	70	22,285	25,900	-13.96
KA 3	5.10x5.18	70	22,443	26,950	-16.72
KB 1	5.05x5.20	70	21,440	28,000	-23.42
KB 2	5.10x5.15	70	21,913	26,250	-16.52
KB 3	5.00x5.10	70	22,238	26,250	-15.28
TA 1	5.20x5.20	70	23,060	30,100	-23.38
TA 2	5.00x5.00	70	21,625	28,875	-25.10
TA 3	5.10x5.20	70	18,755	29,925	-37.32
TB 1	5.00x5.00	70	21,375	27,125	-21.20
TB 2	5.00x5.20	70	24,066	28,875	-16.65
TB 3	5.00x5.20	70	24,066	29,225	-17.65

Average L/h = 13.53

Average h/b = 1.02

Average error = -19.90 %

TABLE 6.3 STATISTICAL DISTRIBUTION OF DANG, KIEM AND TENG WOOD.

	σ_t kg/cm^2	σ_c kg/cm^2	$n = \frac{\sigma_t}{\sigma_c}$	R kg/cm^2
DA 1	1,479	704	2.101	184
DA 2	1,470	720	2.041	186
DA 3	1,488	703	2.116	184
DB 1	1,374	599	2.294	161
DB 2	1,468	724	2.027	186
DB 3	1,340	679	1.973	174
KA 1	1,278	690	1.852	172
KA 2	1,175	705	1.667	168
KA 3	1,161	680	1.707	164
KB 1	1,215	612	1.985	157
KB 2	1,165	666	1.749	162
KB 3	1,318	678	1.944	171
TA 1	1,338	620	2.158	164
TA 2	1,352	675	2.003	173
TA 3	813	654	1.243	136
TB 1	1,380	651	2.120	171
TB 2	1,404	692	2.029	178
TB 3	1,419	682	2.080	178
Mean ; $\bar{X}$	1,313	674		170.5
Std. Deviat$^{\underline{n}}$; $\overline{SD} = \sqrt{\frac{(X-\bar{X})^2}{n-1}}$	160.25	34.49		12.03
Coefficient of Variation ; $CV = \frac{\overline{SD}}{\bar{X}} \times 100$	12.20	5.12		7.06

R = Coefficient of ultimate bending moment for rectangular beam.

6.2 Conclusions

From the test results and the theoretical computations, conclusions may be stated as follows:

1) The usual assumption in beam analysis that plane sections remain plane during bending is satisfactorily proven.

2) The neutral axis of the beam gradually shifted toward the tension side as a result of the stress redistribution across the critical depth.

3) The second degree parabola approximation for the compression stress as suggested by Brochard also Borislav D. Žakic is suitable for Dang, Kiem and Teng wood beams.

4) For small cross sectional beam with depth over width ratio (h/b) equals to 1.0, second degree parabola approximation gives the analytical results 19.90 percent lower than the actual values.

For larger depth over width retio (h/b) equals to 3.92, second degree approximation gives the analytical results 7.10 percent higher than actual values.

5) For general rectangular cross sectional beam, second degree parabola approximation gives the average analytical results 6.40 percent lower than the actual values.

6) Based on this limited investigation, the suitable factors applied in the flexural formula for hard wood are recommended as followed.

Ultimate moment $M_{UL} = Rbd^2 = 142.5\ bd^2$ kg-cm.

Allowable moment $M = 23.8\ bd^2$ kg-cm.